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(54) Abstract Title
GPS correction data on the internet

(57) In a universal ranging system, e.g. a satellite global positioning system (GPS), correction data is relayed from a reference station 31 to a receiver 23, 25, receiving data from the universal ranging system, via the Internet 1 in real time, e.g in less than twenty seconds. Preferably the universal ranging system is a differential global positioning system and the reference station, which is a ground station with known spatial and temporal coordinates, receives signals from the GPS satellites and transmits either range or time correction data to the receiver which uses GPS to define its location. Preferably the Internet link is bi-directional and uses a standard Internet data transferal protocol such as IRC, TCP or IP. There may be a number of receivers all connected via the Internet with a number of reference stations, each receiver receiving correction data from the closest reference station (typically less than 100 miles). Control and maintenance data may be transmitted to both the receivers and reference stations from data monitoring and input means 27,29. The data transmitted may contain status information for verifying its validity and encryption techniques may be used to ensure only known receivers may access the data. An apparatus (Figure 3), including software, for connecting a receiver to the Internet for obtaining correction data is also disclosed.
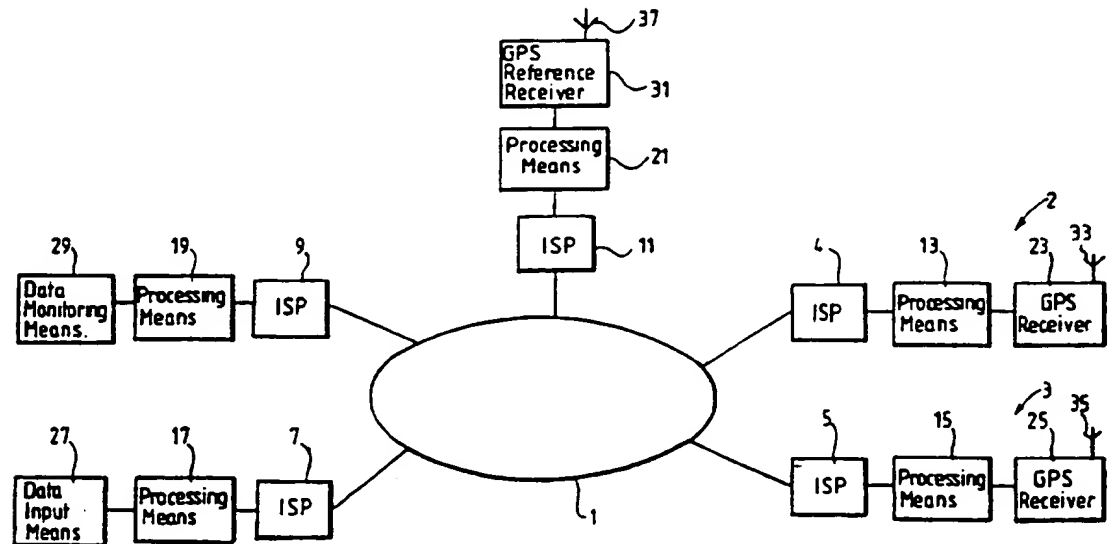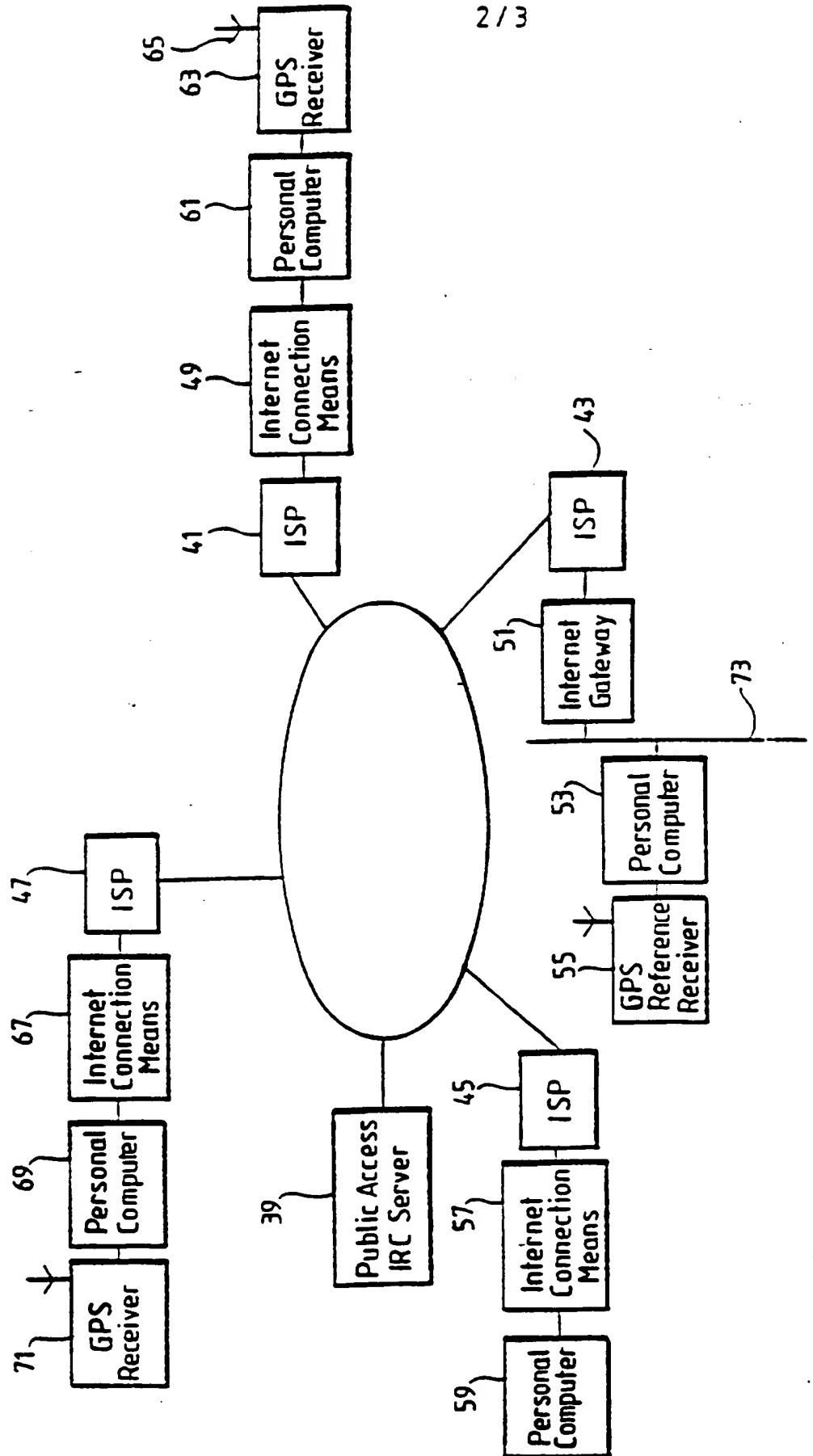
FIG.1.

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG.2.

POSITIONING SYSTEM

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This invention relates to apparatus and methods for transmitting and receiving correction data for a universal ranging system such as the Global Positioning System (GPS).

10 GPS is an example of a passive pseusorandom noise (PRN) ranging system. Signals received from GPS satellites allow the determination of three-dimensional position (X, Y and Z) and time data at a GPS receiver by measuring the range of the receiver from a number of satellites. The position data is used for navigation and surveying purposes, whilst timing data (provided by highly accurate clocks in the satellites) allows the
15 receiver to act as a time or frequency reference which may be used, for example, to synchronise data switches in digital telephone exchanges.

Accuracy is limited by natural (atmospheric) losses, and also by intentional degradation of the data made available to civilian users. It is possible to improve the accuracy of the
20 received data by means of Differential GPS (DGPS) techniques. In a DGPS system the ranges of the GPS satellites are measured from a so-called reference receiver which is located at an accurately known position on earth and/or has an accurate timing reference communicated to it, and, from these measurements, estimates of the range, position and timing errors are calculated. These estimates are then used to provide DGPS correction
25 data to improve the position and timing accuracy of other GPS receivers which are located quite close to the reference receiver, typically within 100 miles.

As such, a conventional DGPS system requires a communications channel to be established between the reference receiver and each of the other GPS receivers, which
30 are hereinafter called 'local' receivers. Such a channel is usually a point to point dedicated channel established for the purpose of providing a data path between the reference receiver and a local GPS receiver. The channel has to be established at the cost and convenience of the user. As the required number of local receivers becomes large, the cost and complexity of establishing the communications channel

sending control signals over the same Internet channel from the remote location, the receiving circuitry can be controlled remotely for improved reliability and for performing other control and maintenance functions, including updating software in the unit or the receiving circuitry.

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The processing means of the interface unit may use an Internet application protocol capable of data transfer between a single remote data source and a single receiver (one-to-one communication), between a single data source and a plurality of receivers simultaneously (one-to-many communication), between a plurality of data sources and a

10   single receiver (many-to-one communication), and between a plurality of data sources and a plurality of receivers simultaneously (many-to-many communication). As such, data may be communicated from a single data source to one other GPS receiver or to a plurality of GPS receivers. Further, data associated with a plurality of GPS equipment may be monitored by one or a plurality of monitoring terminals, connected to the

15   processing means. An example of such an application protocol is the Internet Relay Chat (IRC) protocol, which is capable of real time data transfer in a time interval of less than 20 seconds.

The interface unit may be incorporated in a universal ranging system receiver unit for

20   receiving, for instance, GPS satellite ranging signals, the receiver unit including ranging signal receiving circuitry connected to the processing means so as to receive Differential GPS (DGPS) correction data transmitted via the Internet. The GPS receiver unit is arranged to process the received satellite ranging signals in combination with the correction data to compute corrected GPS data. The DGPS correction data may

25   comprise positional correction data so as to enable a corrected position to be computed, or alternatively, the correction data may comprise timing correction data so as to enable a corrected reference timing signal to be produced.

The invention also includes apparatus for generating corrected output data using signals

30   received from a universal ranging system, comprising a reference receiving station and at least one local receiving station arranged to receive the signals at different geographically spaced locations, the reference station further being arranged to generate correction data for the or each local station wherein the reference station and the or each

Figure 1 is a block diagram of a differential GPS system embodying the present invention;

Figure 2 is a block diagram of an alternative differential GPS system embodying the present invention; and

Figure 3 is a functional block diagram of control software for an interface unit used in the systems of Figures 1 and 2.

The systems described below allow GPS data to be both transmitted and received via an Internet channel. In the description, references made to an 'Internet channel' refer to a channel established over what is commonly known as the 'Internet', i.e. the worldwide network of interconnected sub-networks. Data is transported using the Transport Control Protocol/Internet Protocol (TCP/IP) suite. The TCP/IP transport layer protocol provides for end-to-end data transmission, including routing between networks.

As shown in Figure 1, GPS data is transmitted and/or received over the Internet 1 using processing means 13, 15, 17, 19, 21 which are configured to act as interface units connectible to the Internet 1 and so as to transmit or receive data in real time. In this case, each processing means is connected to the Internet 1 via an Internet Service Provider (ISP), which may provide particularly convenient access using Internet connection means (i.e. a modem) and standard telephone lines to dial up the ISP. As an alternative, larger organisations may obtain direct access to the Internet using leased lines to connect their local area network (or intranet) to the Internet.

By using the Internet 1 to transmit such GPS data, it is possible to establish data communications channels between a large number of terminals at different locations for transmitting and receiving data, and without having to establish dedicated channels. In this way, GPS data may be transmitted to and received from any location where Internet access can be achieved.

The GPS data comprises Differential GPS (DGPS) correction data. Such data may initially be output from a so-called GPS reference receiver 31. The reference receiver

transport-level suite. The Internet application protocol is a communications protocol the data communication standards of which are arranged to enable data transfer suited to particular applications. Typical application protocols include the File Transfer Protocol (FTP), which provides a mechanism to facilitate the transfer of files between computers, and the Internet Relay Chat (IRC) protocol, which provides for real-time data conferencing over the Internet 1.

Communication via the IRC protocol is facilitated by a public access IRC server. The IRC protocol, when operated over the Internet, provides a teleconferencing system which enables real-time, one-to-one, one-to-many, many-to-one and many-to-many data transfer operations, typically enabling reception within a time period of 20 seconds from the data being transmitted. The IRC protocol operates over networks of IRC servers (the Internet 1 itself comprising networks of many different types of server) which may be connected to each other in a distributed manner. Users, or in this case, processing means, may access other processing means (and so establish a communications channel over which GPS data can be transported) by connecting to the IRC servers using a program, or 'client'. This means that at any one time, thousands of channels may exist over the Internet 1, each channel possibly being accessed by many users. Since the servers are themselves connected, processing means are able to communicate with each other across the globe in real time. The IRC channel may be created by a so-called 'operator' who is able to determine which users (or processing means) are able to communicate over that particular channel. The operator has certain powers to remove users or refuse users initial access to the channel. In this way, access to the channel transporting the GPS data may be restricted, for instance by way of a program which requires a password to be entered before access to the channel is allowed.

The transfer of data between a data source (e.g. reference receiver 31) and processing means such as the associated processing means 21 is performed in real-time to provide frequent and up-to-date refreshing of data. The IRC protocol allows positional correction data to be fed to a mobile GPS receiver within a matter of seconds, typically 5 seconds, of being transmitted. It should be understood that the term 'real-time'

the form of DGPS correction data is output from apparatus comprising a GPS reference receiver 55 which is connected to a corporate intranet 73, and processing means in the from of a personal computer (PC) 53. Other PC's and GPS apparatus may be connected to the Internet 1 via the intranet 73. The intranet channel 73 provides access to the

5   Internet 1 via an Internet gateway 51 which is connected to an Internet Service Provider (ISP) 43. Also connected to the Internet channel are two GPS local receivers 65, 71 connectible to the Internet 1 by processing means in the form of PC's 61, 69 and Internet connection means 49, 67 which access the Internet 1 through ISP's 41, 47. Processing means in the form of PC 59 is connected to the Internet 1 by Internet

10   connection means 57 through ISP 45. This PC acts as both data input means and data monitoring means to enable efficient operation of the GPS equipment. This configuration allows DGPS time and positional data to be transmitted from the GPS reference receiver 55 for transport over the Internet 1 for ultimate reception by the GPS local receivers 65 and 71. Furthermore, the status of the receivers 55, 65, 71 can be

15   monitored using the PC 59, which can be used to adjust receivers 55, 65, 71, by allowing the transmission of control and maintenance data in the opposite direction.

As shown in Figure 2, the established channel is created by connecting to a public access IRC server 39 over the Internet 1. Data which is placed on the Internet 1, e.g. the

20   DGPS correction data output from the reference receiver 55, is accessed by the GPS receivers 63, 71 via the PC's 61, 69 to which they are connected, these PC's being configured by a program as interface units to access the channel and to use the IRC protocol to receive the data. Data input and monitoring PC 59 similarly uses such a program to act as an interface unit accessing a different channel, or channels, in order to

25   be able to transmit control and maintenance data, and monitor status data. Such a program may access the channel by prompting the user for a password, obtained by way of subscription payment to the data provider.

The PC's 53, 59, 61, 69 are configured so as to be connectable to the Internet 1, and

30   more particularly to the IRC server 39 by means of interface software. This interface software enables the Internet data to be transmitted and received according to the IRC protocol, and the physical input/output port of each PC is correspondingly configured.

The data monitoring PC may be used to input so-called 'maintenance date' for transmission over the Internet 1. Maintenance data is used to set up and/or update software in the system. In this embodiment, the PC's 53, 61, 69 attached to GPS

5   receivers are programmed to use the Internet Relay Chat (IRC) protocol. The required software can initially be sent to and set up in the PC's 53, 61, 69 remotely from the monitoring PC 59. Later, upgraded software may be sent across the Internet 1 from the monitoring PC 59 to other users who require the so-called maintenance data.

10   Referring to- Figure 3, the interface software 81 contains functional blocks for controlling the processing means which act as the data interface units, as shown in and described with reference to Figures 1 and 2. Physical Port 80 shown in Figure 3 comprises a standard serial port which is found on most personal computers for feeding data to external devices. In the embodiment of Figure 2, the GPS receivers 55, 63, and

15   71 are connected to the physical ports of the associated PC's 53, 61, and 69 respectively. Those skilled in the art will recognise that 'WinSock Layer' 82 shown in Figure 3 refers to the software mechanism provided by most PC operating systems which enables the PC to communicate over the Internet using the TCP/IP protocol. In this instance, the WinSock Layer if each PC provides a driver interface with its

20   respective internet connection means.

The internet software 81 has the following interacting functional blocks or modules: MSCOMM.OCX 83 and MSCHAT.OCX 84, encryption and descryption routines 85, command interpreter 86, and initialisation and control routines 87.

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MSCOMM.OCX 83 is a commercially available software package for setting up and controlling computer ports. The package provides programmers with a tool for setting up and controlling the behavioural attributes of ports, examples of such attributes being the baud rate, the stop bits, and the interrupts. The software package itself is freely

30   downloaded via the Internet from the World Wide Web and is also available as part of the so-called Software Developer's Kit available from Microsoft, Inc. In this embodiment, the setting up and control tool is controlled by the other software

reference receiver and PC's or other external devices via the Internet 1, using the IRC protocol. Accordingly, control data fed to the monitoring PC 59 can be transferred via the port and the OCX module 83 to the OCX module 84 for transport using the IRC protocol, e.g. to change control parameters of the reference receiver 55. It should be noted that external devices which have no manual control interface, such as the GPS receivers 55, 63 and 71 are able to feed signals via the command interpreter 86 for transfer over the Internet 1. Such a receiver may be configured to output command signals in certain circumstances e.g. to close its own link with the Internet in a power-save operation, if it determines that no new data has been received over a period of time. Such commands may be used to control the software, and so control the communication of data from particular external devices over the Internet 1.

The encryption and decryption routine module 85 provides a secure, bi-directional data path through which the actual universal ranging data is transferred between the Internet 1 and the respective external device via the physical port 80. Data security is achieved using known data encryption and decryption techniques. Such security restricts data to authorised users, be they subscribers who wish to use correction data, or system supervisors who need to be able to look at the status data. In effect, module 85 provides a transparent link between the respective external, physical, device and the Internet. It also ensures that only authorised users are able to actually obtain access to the data.

correction data from the communications port to the correction data output using the IRC protocol.

6.   An interface unit according to any preceding claim. wherein the Internet application protocol used by the processing means is capable of data transfer between a data source and a receiving apparatus in a time interval of less than 20 seconds.

7.   An interface unit according to any preceding claim. wherein the Internet application protocol allows data transfer between one data source and one receiver for receiving signals from a universal ranging system. or between one data source and a plurality of such receivers simultaneously.

8.   An interface unit according to claim 7. wherein the Internet application protocol further allows data transfer between a plurality of data sources simultaneously and one said receiver, and further between a plurality of data sources simultaneously and a plurality of said receivers simultaneously.

9.   A universal ranging system receiver unit including receiving circuitry for receiving ranging signals from a universal ranging system and incorporating a correction data interface unit according to any preceding claim. the interface unit being connected to the said ranging signal receiving circuitry.

10.   A receiver unit according to claim 9. including processing means dedicated to transferring data between the communications port and the receiving circuitry.

11.   A receiver unit according to claim 9 or claim 10. arranged to generate position data from a plurality of signals received from satellites of a satellite ranging system, wherein the correction data interface unit is arranged to process position correction data, received at the communications port thereby to allow generation of a corrected position by the said ranging signal receiving circuitry.

reference station and each local station being configured to transmit and receive respectively the correction data using the said Internet application protocol.

17.   Apparatus according to claim 16. wherein the reference and local receiving stations are GPS receiving stations and the GPS correction data is differential GPS correction data, the corrected output data comprising position data or timing reference data.

18.   Apparatus according to claim 16 or claim 17, further comprising a data monitoring unit for providing a visual output of universal ranging system data and incorporating a data interface permitting transfer of data to and/or from the monitoring unit via an Internet channel using the Internet application protocol.

19.   Apparatus according to claim 18, wherein the data monitoring unit is configured to receive the correction data or status data, the status data being generated by the local receiving stations.

20.   Apparatus according to claim 16, including a data input unit connected to the data interface.

21.   A method of generating corrected output data from ranging signals generated in a universal ranging system, comprising:-

                receiving the ranging signals at a first location.

                receiving, at the first location, real time correction data derived from the ranging signals as received by a reference receiver at a second location geographically spaced from the first location, and

                putting the corrected output data derived from the ranging signals received at the first location and from the received correction data,

                wherein the real-time correction data are received at the first location via an Internet channel by means of an Internet interface unit using an Internet application protocol permitting data transfer from the second location to the first location via the Internet channel in real time.

30. A method according to any of claims 21 to 29, further comprising receiving maintenance data via the said Internet channel and Internet interface unit, and processing the received maintenance data to set up or update software used for the receiving operation at the first location.

31. A method of disseminating correction data for correcting output data generated by at least one receiver receiving ranging signals from a universal ranging system, comprising:

providing a reference receiver at a geographical location,

- receiving the ranging signals using the reference receiver,

- computing real time correction data representative of ranging errors in the received ranging signals,

automatically monitoring an Internet connection associated with the reference receiver, and

in response to receiving a valid request message at the Internet connection from a remote ranging signal receiving location, transmitting the real time correction data via the Internet connection to the remote receiving location using an Internet application protocol which allows transfer of the correction data to the remote location in real time.

32. A method according to claim 29, wherein the Internet application protocol is an Internet Relay Chat (IRC) protocol.

[Add dependent claims to GPS, position, timing, control and maintenance data, receiving status data].

33. A method according to claim 31 or claim 32, wherein the ranging signals are received from a pseudo-random noise satellite universal ranging system.

34. A method according to claim 33, wherein the universal ranging system is the Global Positioning System (GPS).

43. A method of generating corrected output data, the method being substantially as hereinbefore described wit respect to the drawings.

5   44. A method of disseminating correction data, the method being substantially as hereinbefore described with respect to the drawings.

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